DEPARTMENT OF CONSUMER & REGULATORY AFFAIRS

DCRA's Green Building Symposium
Green Before You Bling:
Building Science 101

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Agenda

- Intro to Building Science
- Climate and Site Factors
- Building Science Fundamentals
  - Heat flow
  - Air Flow
- Moisture Affects on Buildings
- Building and Unit Ventilation
- HVAC Sizing and Distribution

How Have Buildings Changed?

Courtesy Enterprise Green Communities

Regional Building

Pacific Northwest

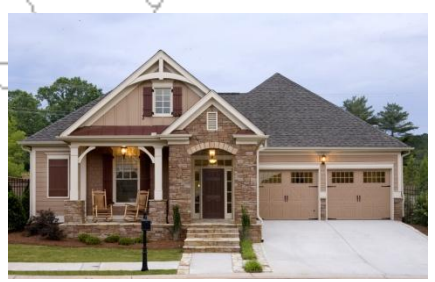
New England

Middle America

Mid-Atlantic

Southwest

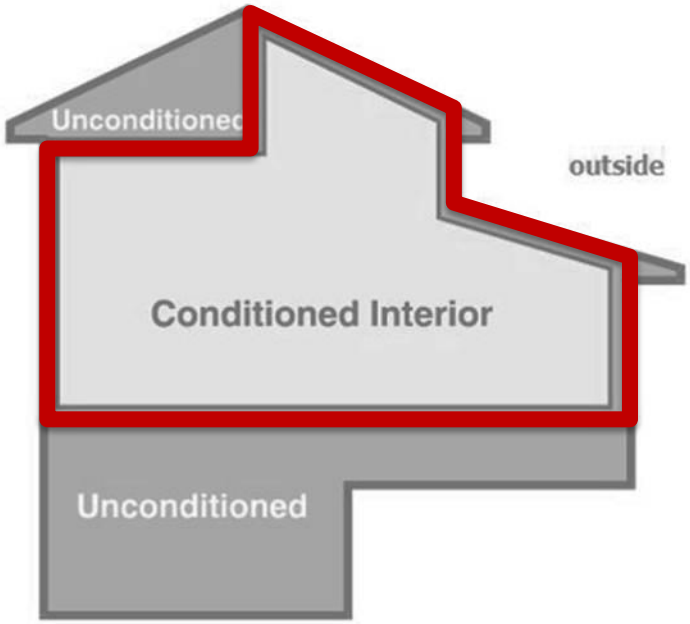
Deep South



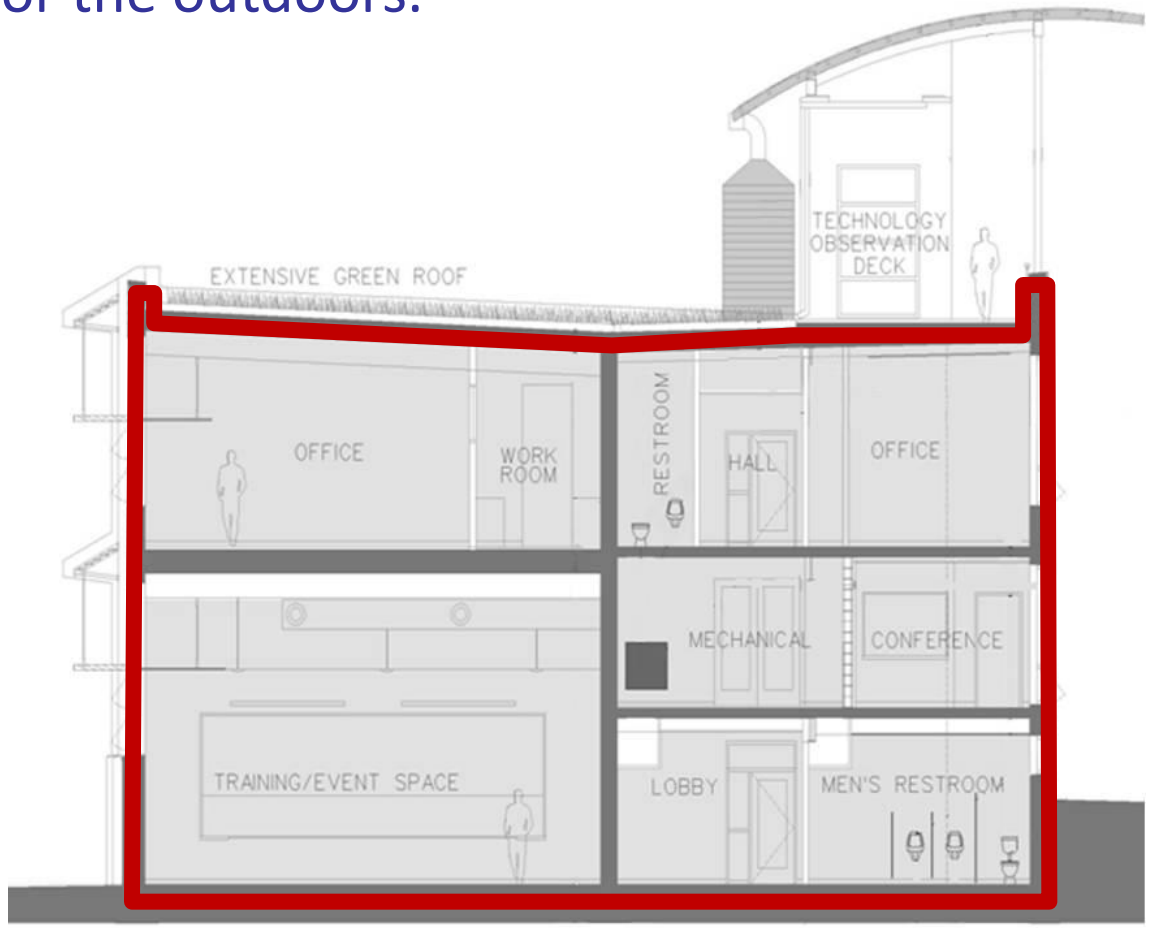
Southeast

Defining Building Thermal Envelope

The "Building Thermal Envelope" represents the boundary that separates conditioned space from unconditioned space or the outdoors.



Residential

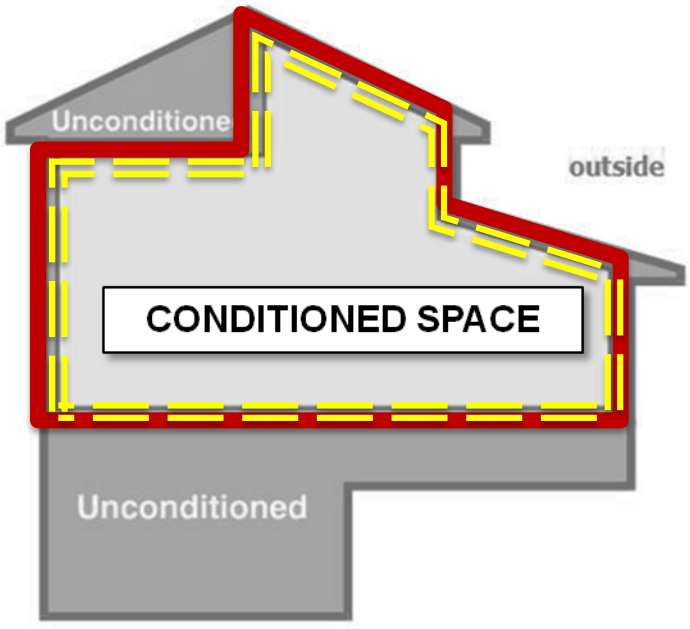


Commercial

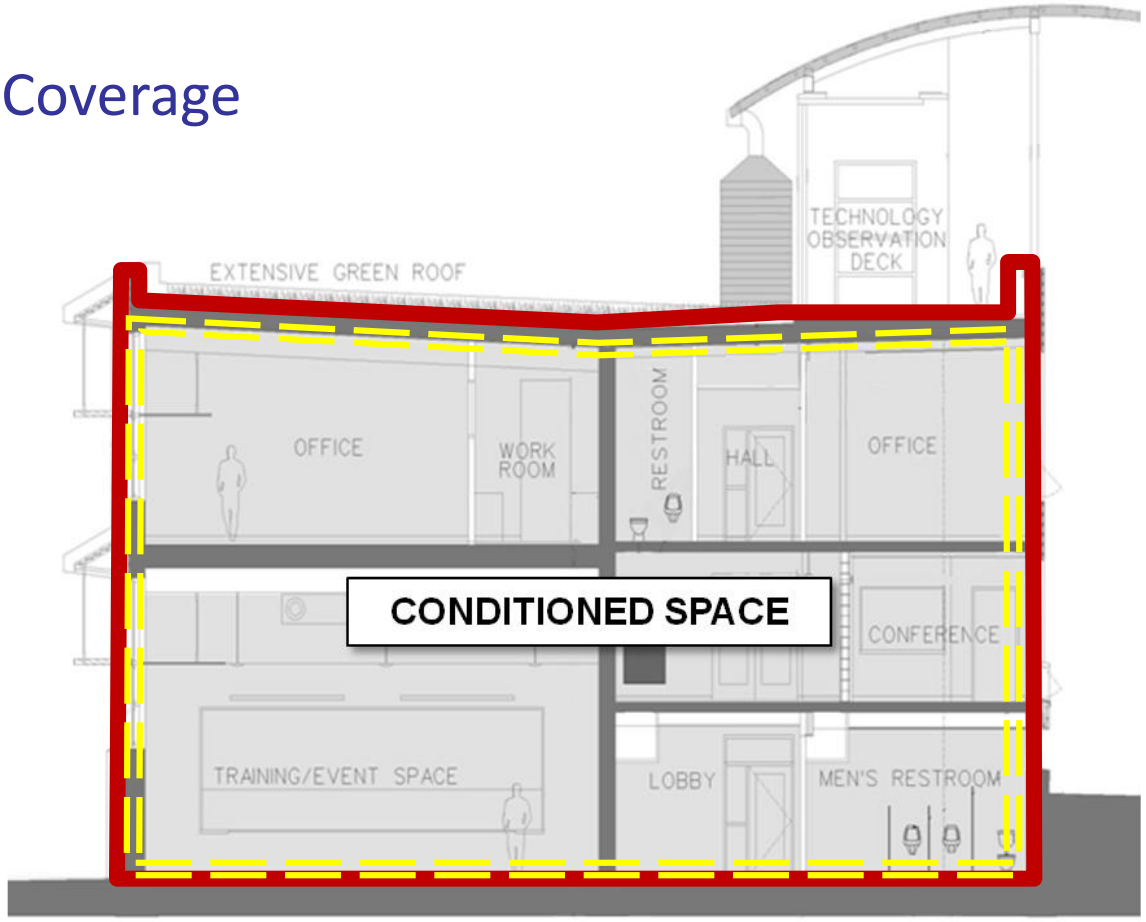
Defining Building Thermal Envelope

Building Thermal Envelope

- Continuous Air Barrier
  (Pressure Boundary)
- Complete Insulation Coverage
  (Thermal Boundary)



Residential



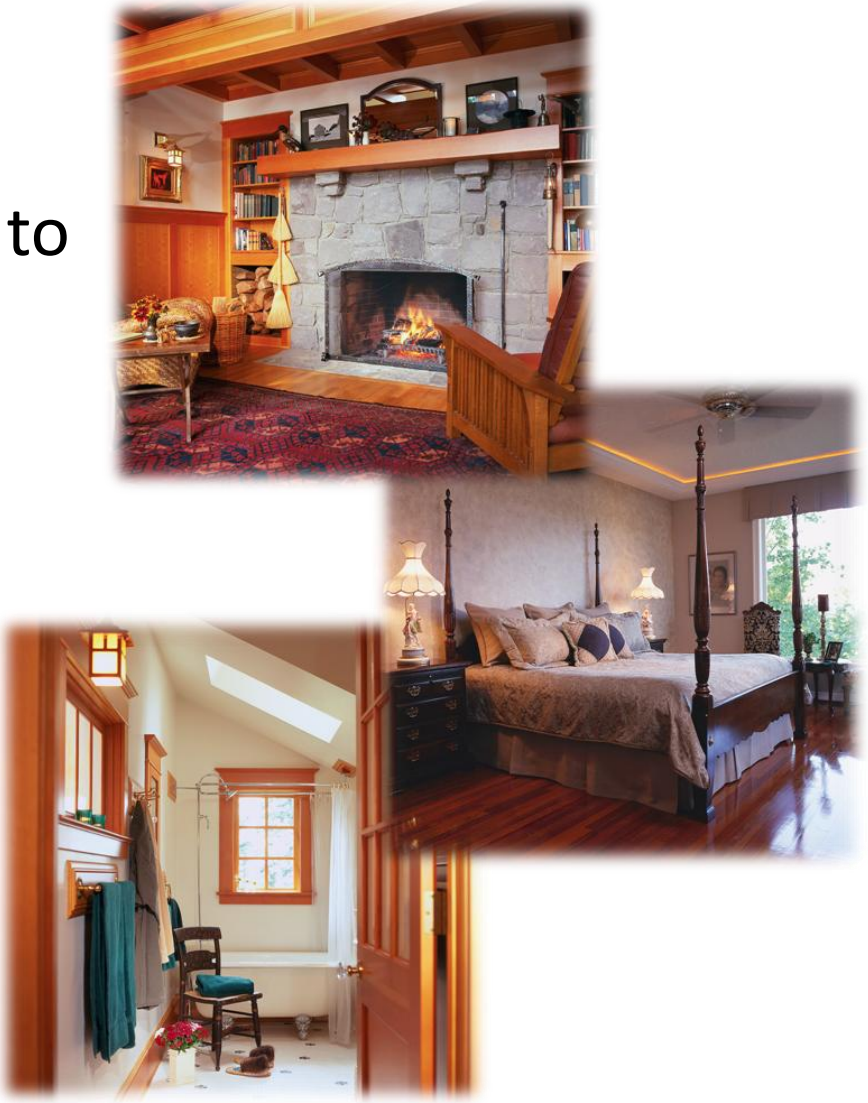
Commercial

Defining Building Thermal Envelope

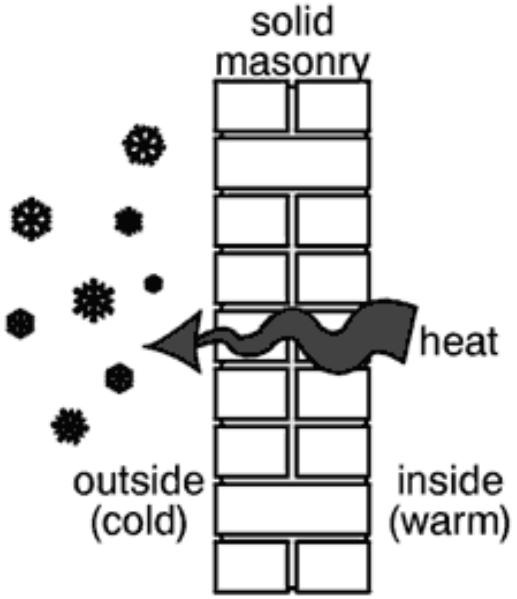
Building Science Fundamentals

CONCEPTS

- Key Physical Properties to Control
  - Heat
  - Air
  - Moisture



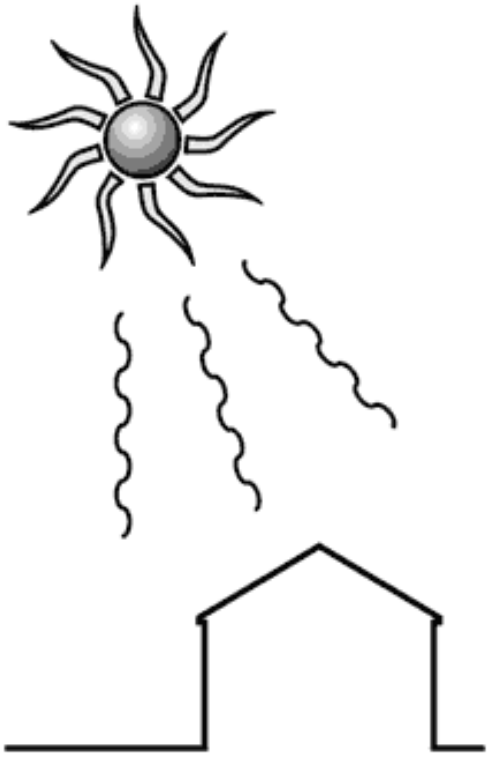
Mechanisms of Heat Transfer



conduction

heat transfer through a solid material

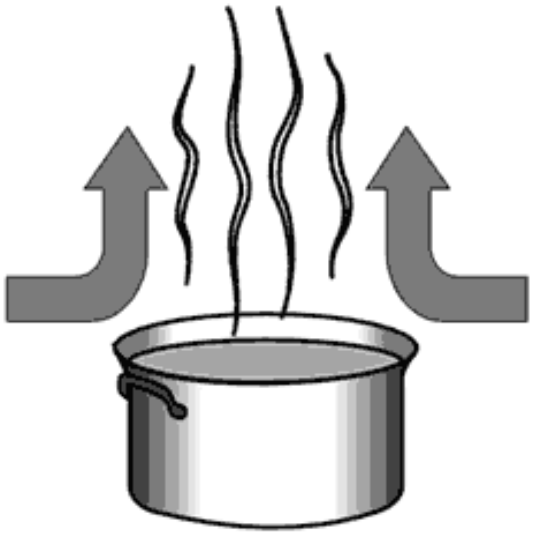
the direction of heat travel is always from hot to cold



radiation

heat transferred through invisible light waves e.g. thermal infrared energy (sunlight)

air above the pot warms up (becomes less dense) and rises - drawing more cool air in from the sides to be heated up



convection

heat transfer within a gas or liquid

Courtesy Enterprise Green Communities

Heat Transfer

Heat always moves from…

a warmer place to a cooler place

- Types of Heat Transfer
  - Conduction (*solids*)
  - Convection (*gas* or *liquids*)
  - Radiation (*surfaces*)

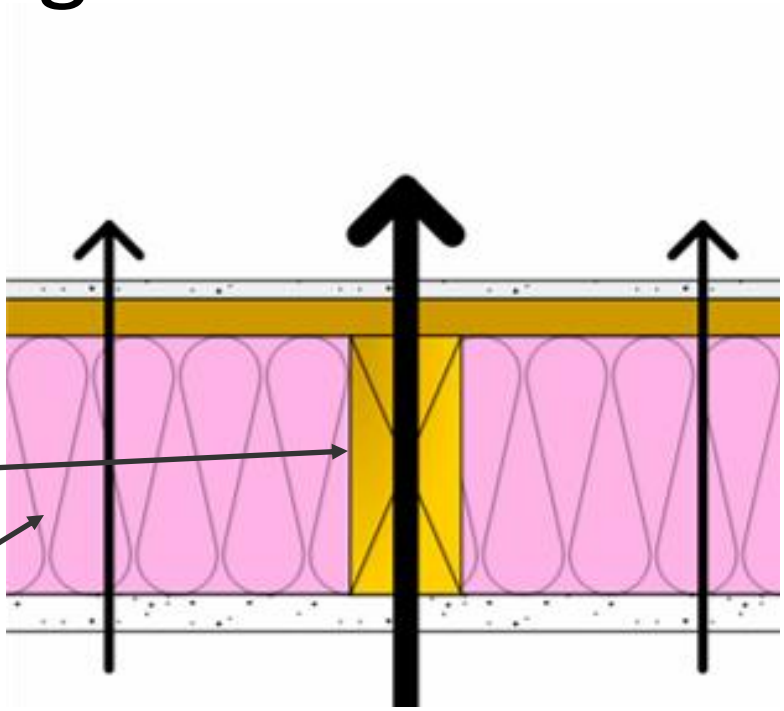
Heat Transfer Demonstration

Thermal Bridging is a Problem

Heat flows more easily through wood studs = Conduction

2” x 6” stud = R-6

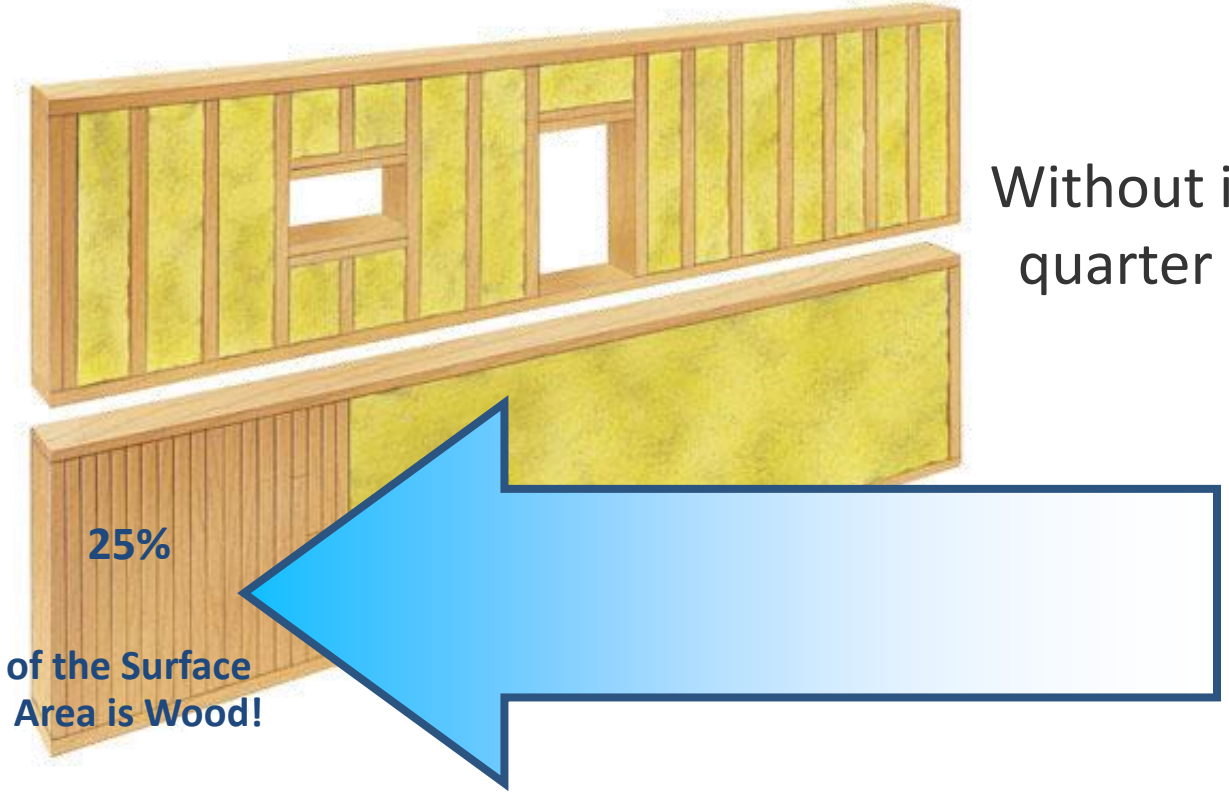
Insulation cavity = R-19+



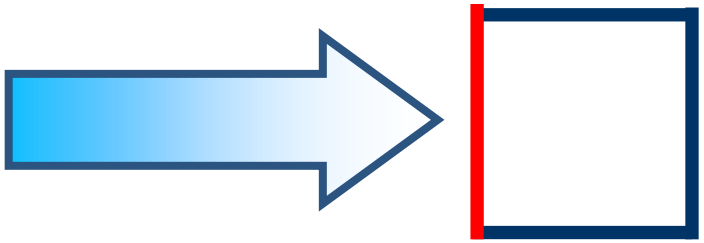
Wood is not a great insulator

Courtesy Enterprise Green Communities

Thermal Bridging – Stud Loss



Without insulated sheathing, a quarter of your walls are not insulated



On a square house, it's the equivalent of one whole wall!

Courtesy Enterprise Green Communities

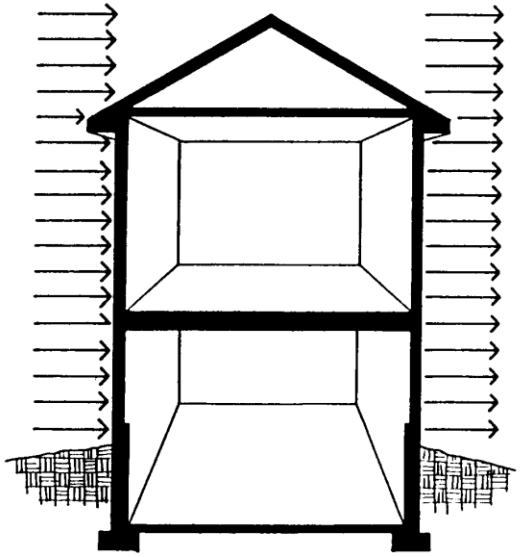
Courtesy Enterprise Green Communities

Air Flow

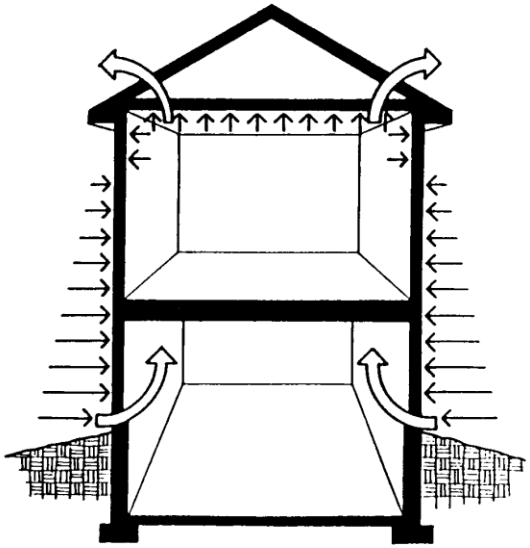
CONCEPTS

Science of Air Flow (Infiltration)

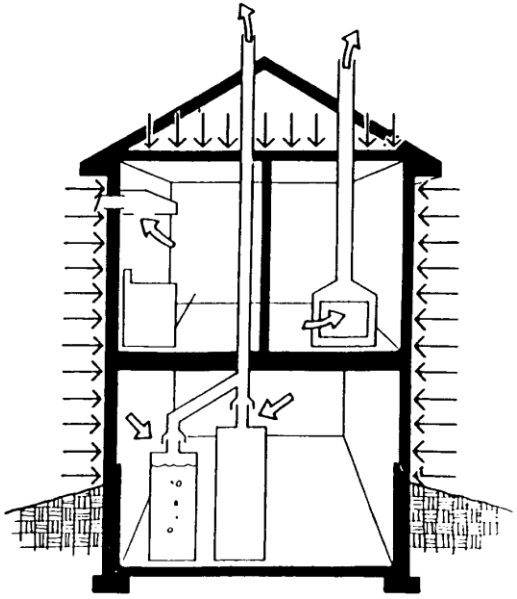
Pressures / Driving Forces



Wind Pressure



Stack Effect

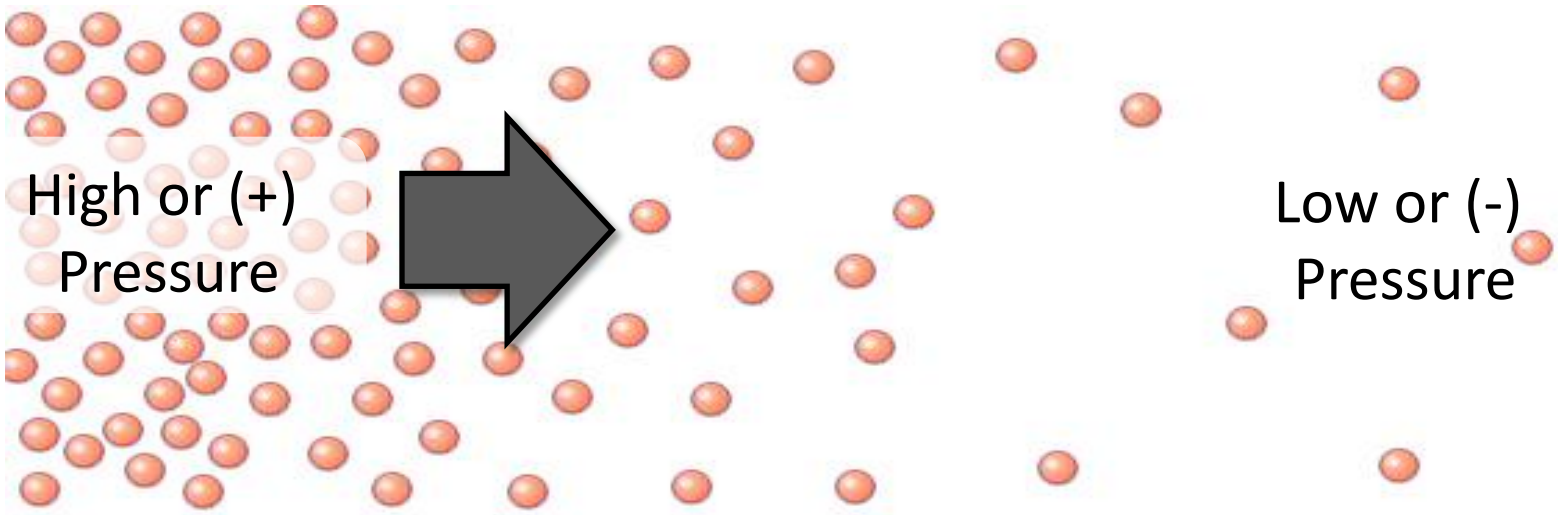


Mechanical Pressure

Air Infiltration

Air always moves from…

high pressure to low pressure areas.

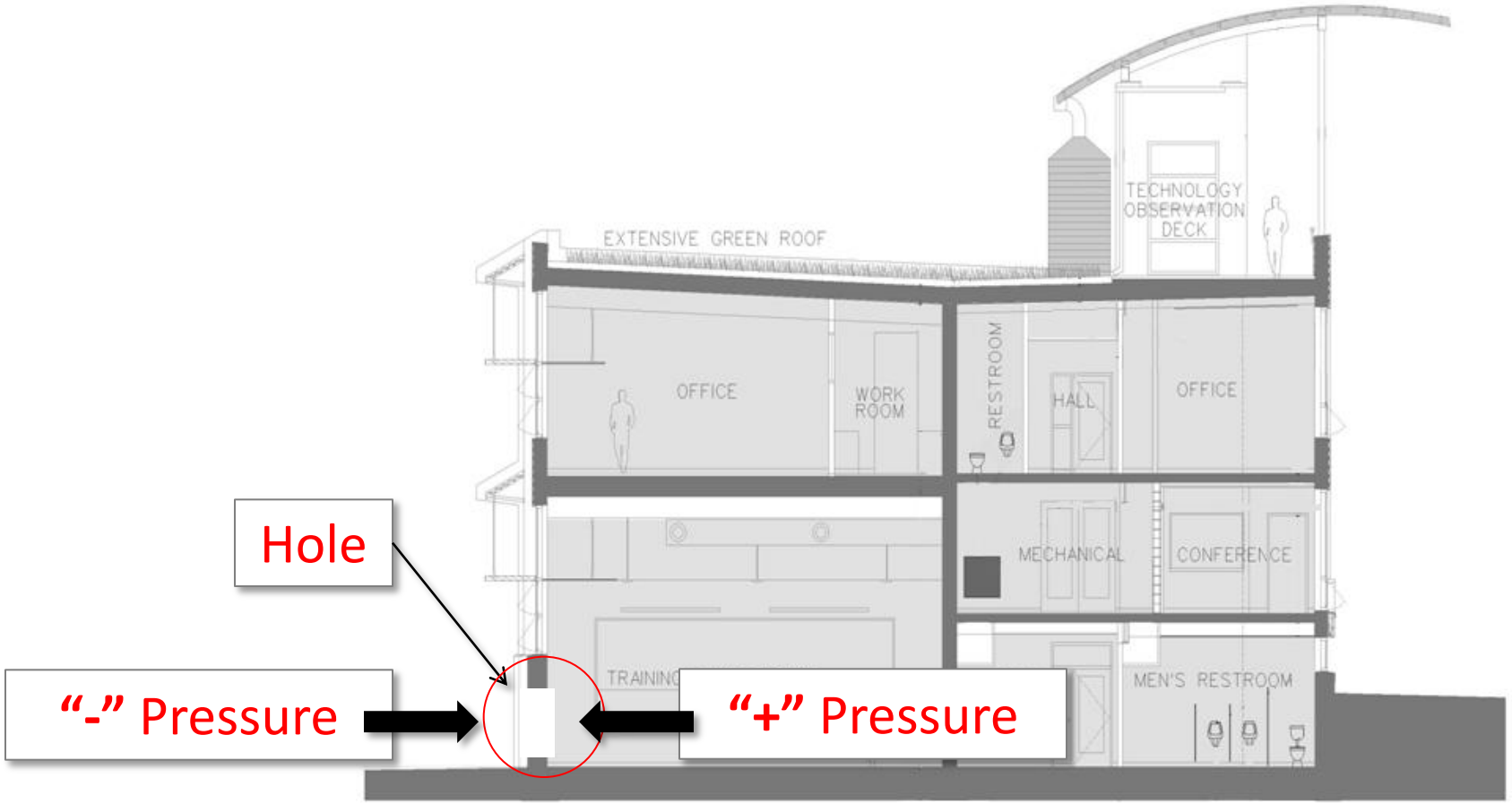


When air moves out of a building, the same amount has to come in and vice-versa.

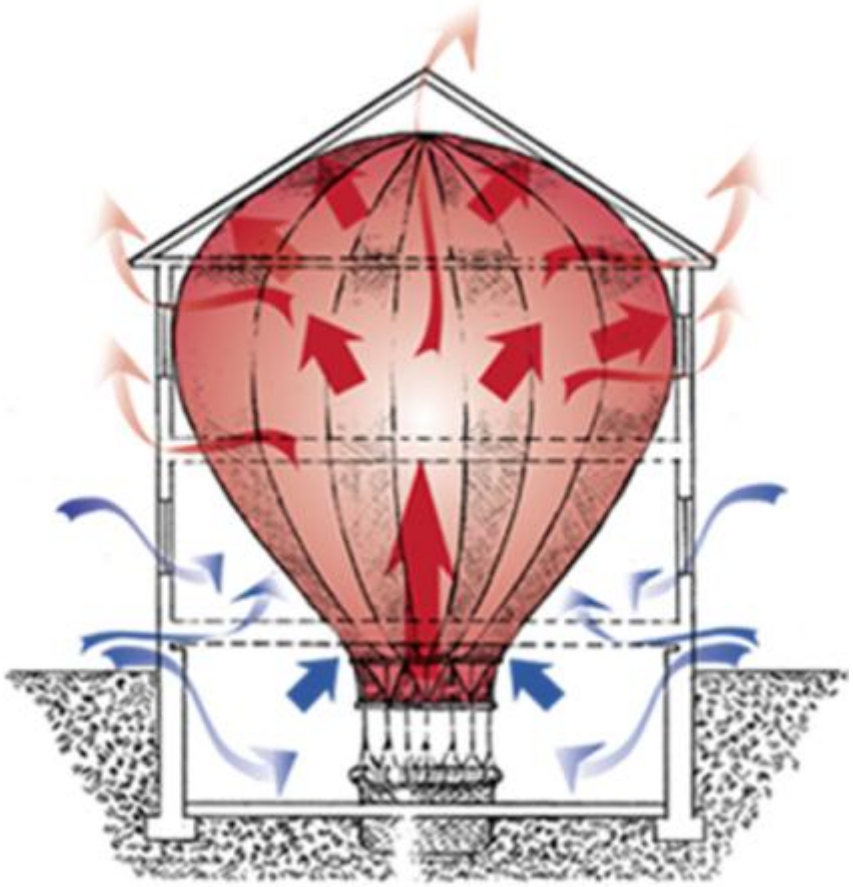
Basic Principles of Air Infiltration

Two requirements for air to move through a building:

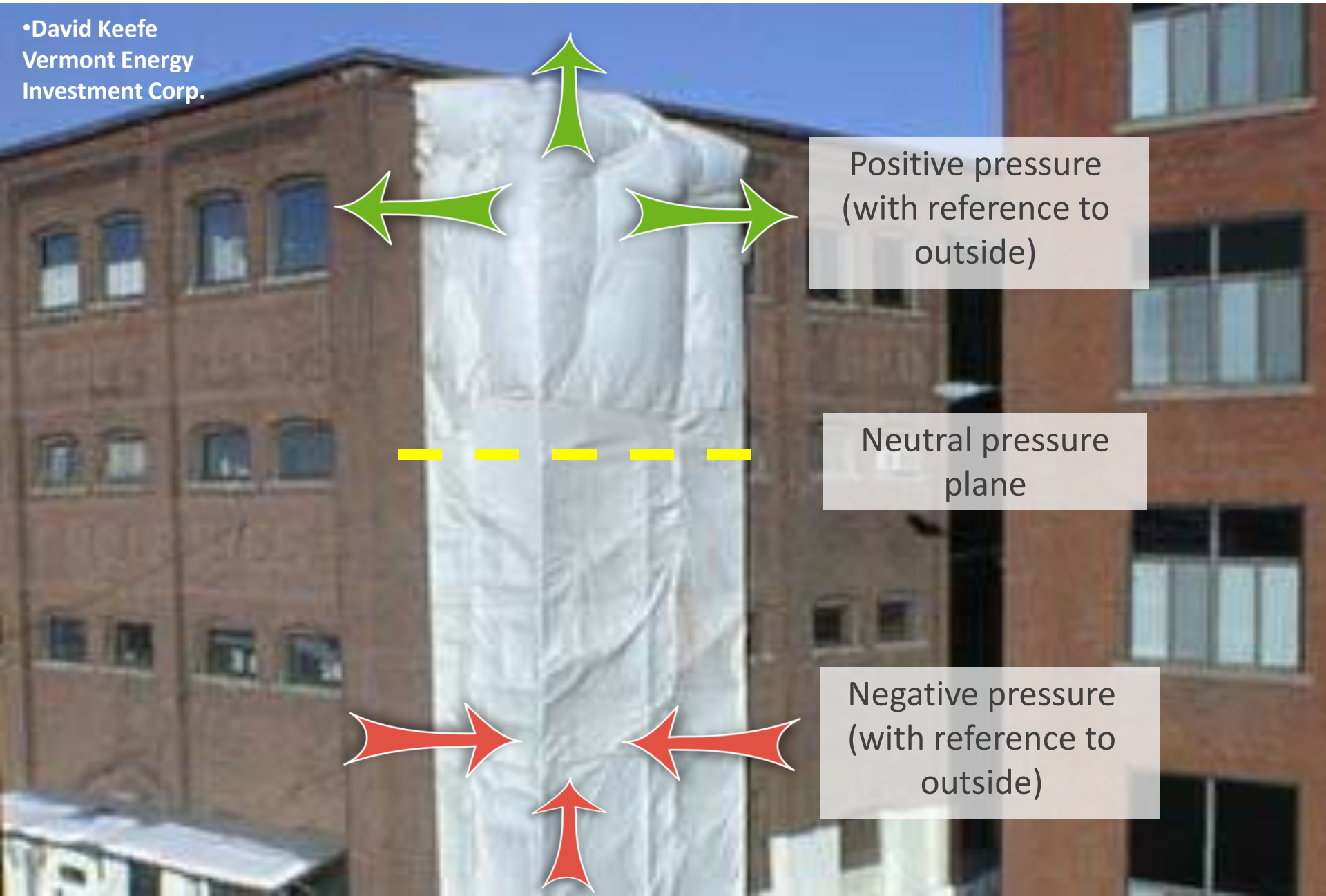
1. Pathway for air movement (a hole)
2. Pressure difference (driving force)



Buildings in Winter are Like Hot Air Balloons



Pressures / Driving Forces



Stack Effect Demonstration

Know Your Code:

Air Sealing and Infiltration

2009 IECC

- **Option 1:** Air Barrier Visual Inspection -

  Must pass inspection checklist of air sealing and properly installed insulation at rough-in inspection before drywall is installed but insulation and air sealing is complete.

- **Option 2:** Blower door testing - Tested leakage must be less than 7 ACH at 50 Pascals of pressure (ACH50) at final inspection when construction is complete.

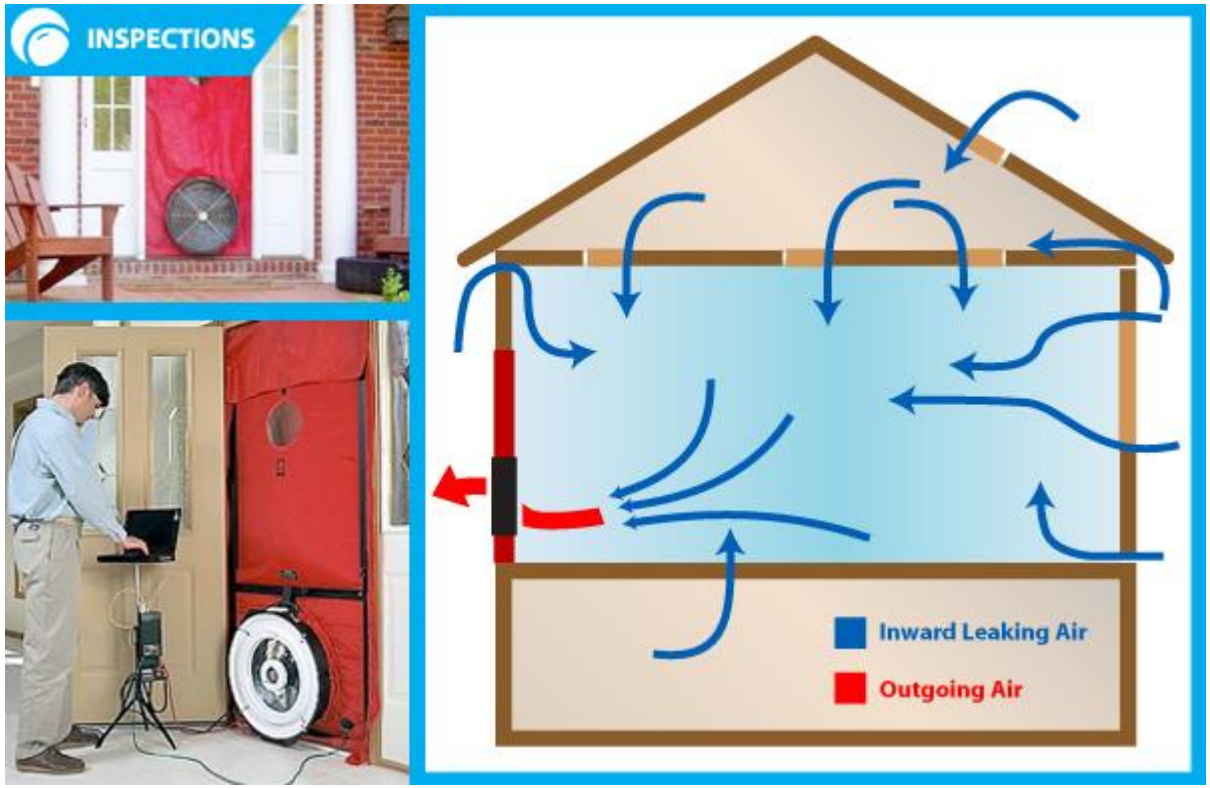
2012 IECC – DC Amendments

- **Air Barrier:** Inspection required, official to decide if it must be third-party

- **Infiltration:** Blower door testing - Tested leakage must be less than 5 ACH at 50 Pascals of pressure (ACH50) at final inspection when construction is complete.

Blower door testing

- 50 Pascals (0.2 IWG)for residential
- 75 Pascals (0.3 IWG) for commercial



Moisture Flow

CONCEPTS

- Bulk
- Capillarity
- Diffusion
- Air Leakage

Uncontrolled air and moisture flow can create rot and decay

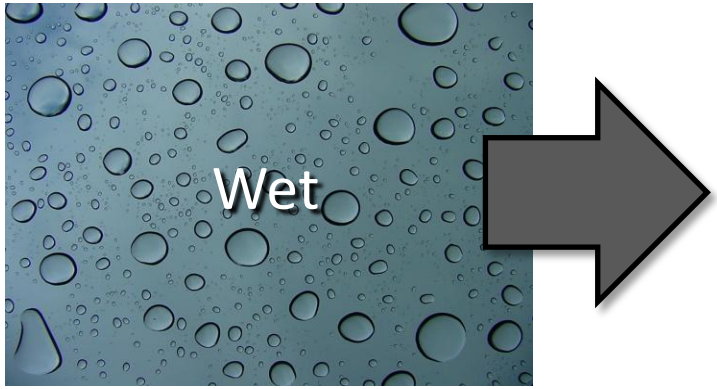
Courtesy Enterprise Green Communities

Moisture Flow in Buildings

Moisture Movement

Moisture always moves from…

wet areas to dry areas.



- Moisture flows in two forms: Liquid and Vapor
- Liquid includes:
  - Bulk
  - Capillarity

Vapor Includes:

Diffusion

Air Leakage

Capillary Flow

Concrete and Wood Wick Water

Concrete can transport water in excess of 1,000 feet

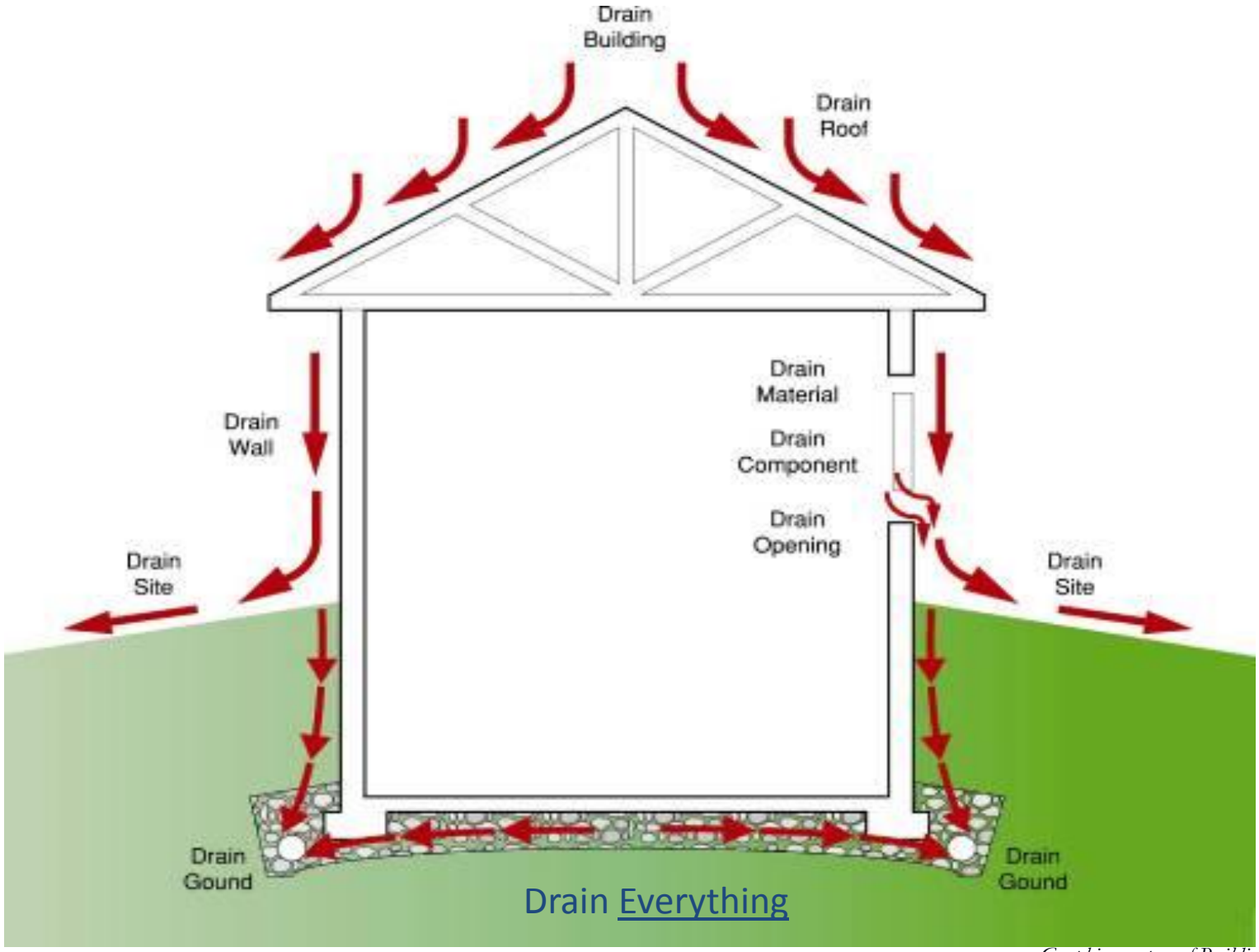
Wood can transport water in excess of 300 feet

Courtesy Enterprise Green Communities

4 Ways to Control Moisture

- Reduce bulk moisture
- Reduce indoor humidity
- Control air leakage
- Increase surface temperature

Reduce Bulk Moisture



Drain Everything

Graphic courtesy of Building Science Corp.

Where is Humidity a Problem?

Anywhere it can hit dew point!

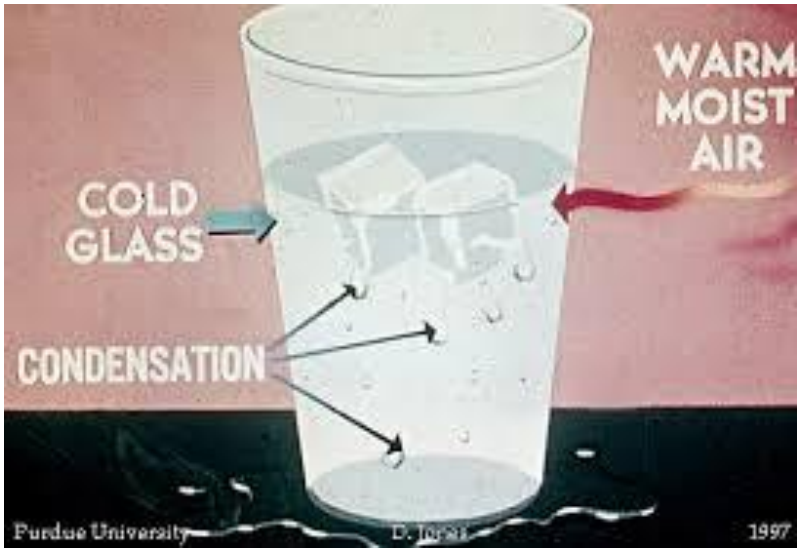
Rust on nail heads

Patches of mold

Rot

Dew Point

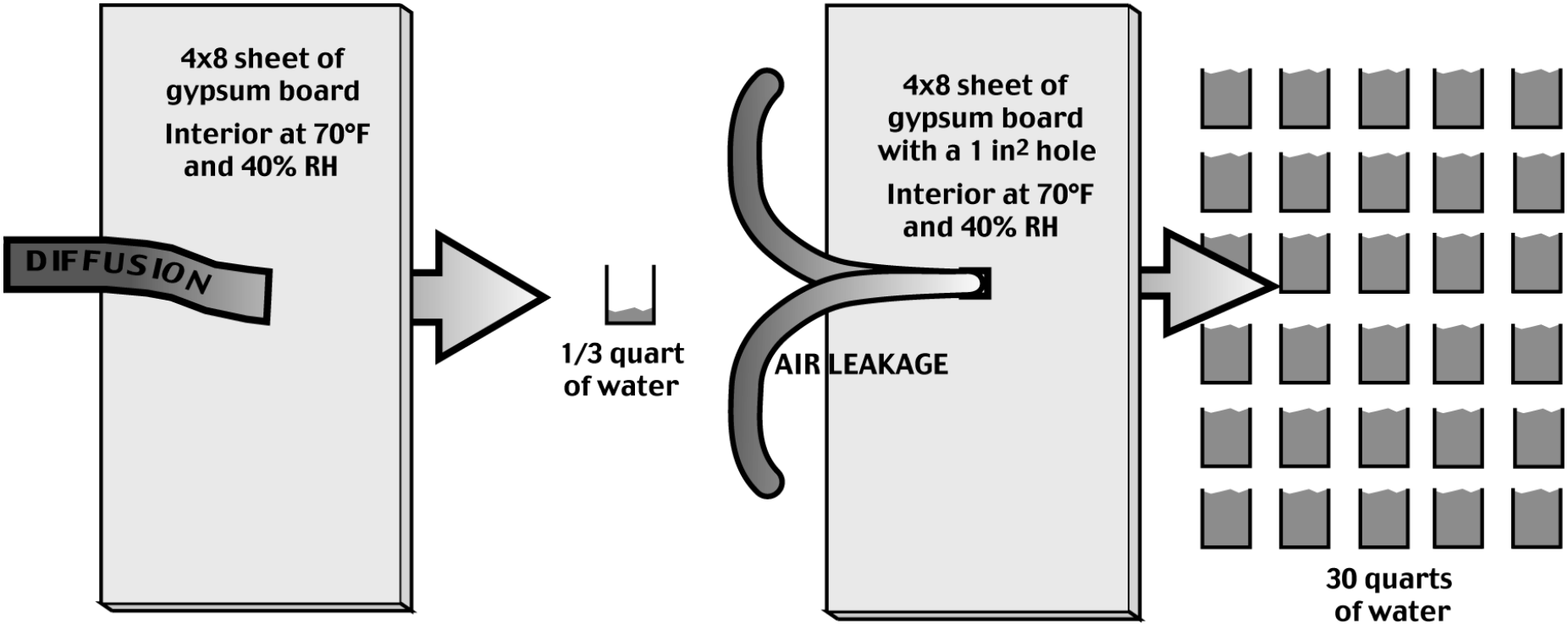
- The **dew point** is the temperature below which the water vapor in air will condense into liquid water at the same rate at which it evaporates.
- The lower the *surface* temperature, the more likely condensation will occur
- The higher the amount of water in air, the more likely condensation will occur



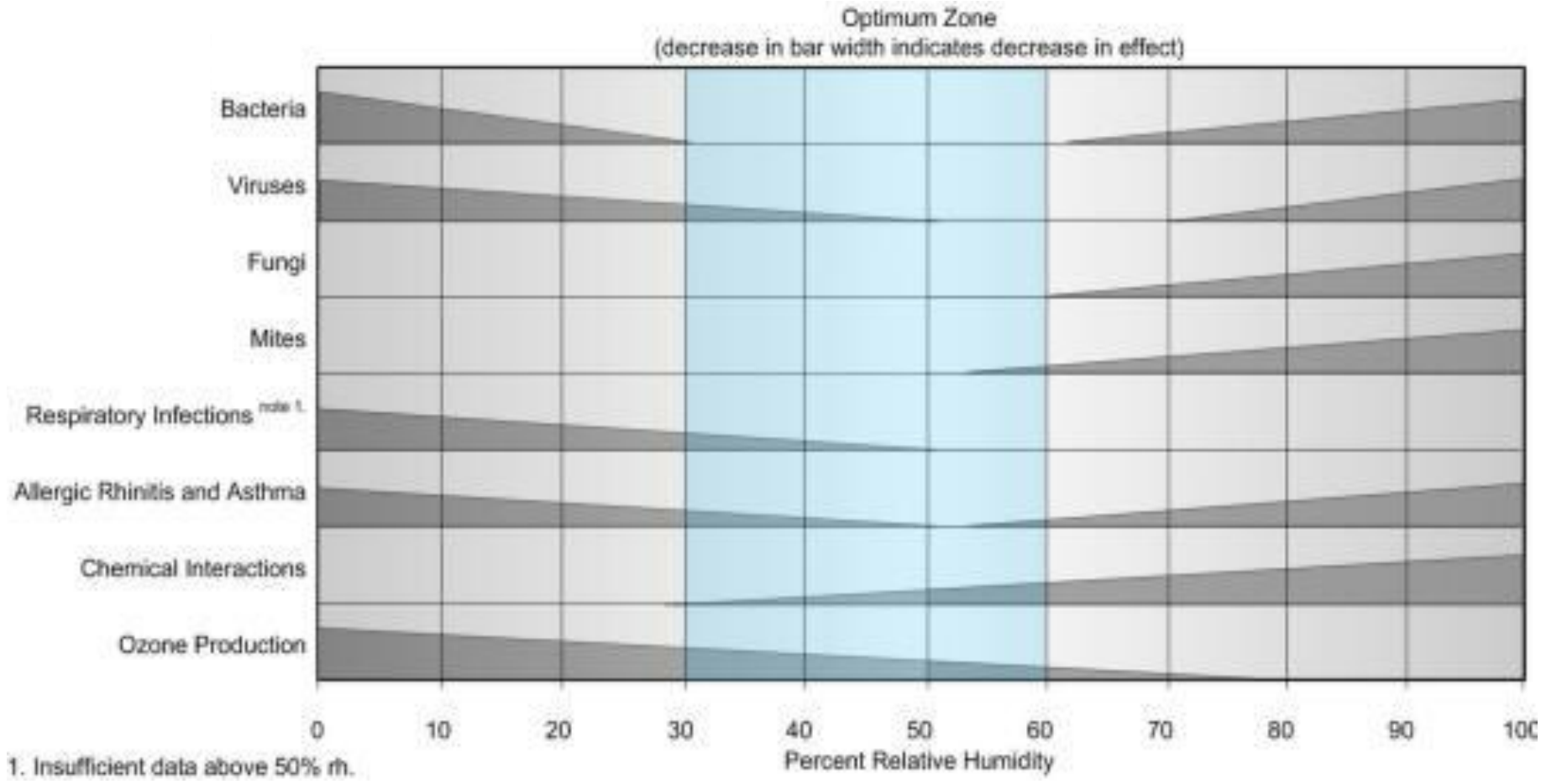
Controlling Dew Point

- Decrease indoor humidity levels
- Increase surface temperatures
  - Install insulation to keep walls warm
  - Install high-efficiency windows

Vapor Diffusion vs. Air Leakage



Health Effects of Humidity



The Need for Mechanical Ventilation

- There are more pollutants in our homes than ever, requiring more ventilation air.
- Homes are tighter than they used to be
- Much of the infiltration that does occur comes from undesirable locations
- Even the portion of infiltration that can be considered “fresh air” varies sporadically based on weather conditions.

Would You Rather Heat and Cool….

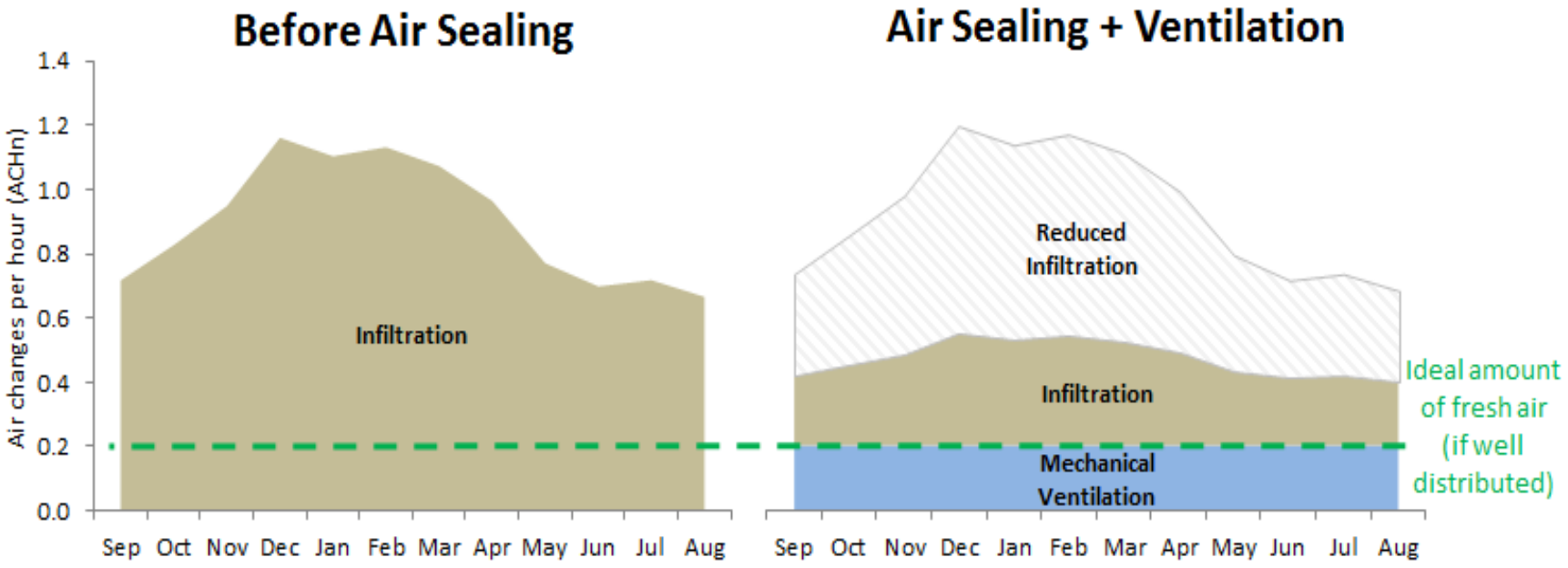
OR

Build it Tight, Ventilate it Right!

Controlled mechanical ventilation:

- Allows control over exactly how much fresh air is delivered and when.
- You can adjust the amount of ventilation air if the occupancy changes (e.g. kids go off to college) or shut it down altogether while on vacation, or when windows are open.
- It delivers a consistent amount of air year-round, no matter what the weather conditions.
- It draws air directly from outside, so the air is guaranteed to be fresh.

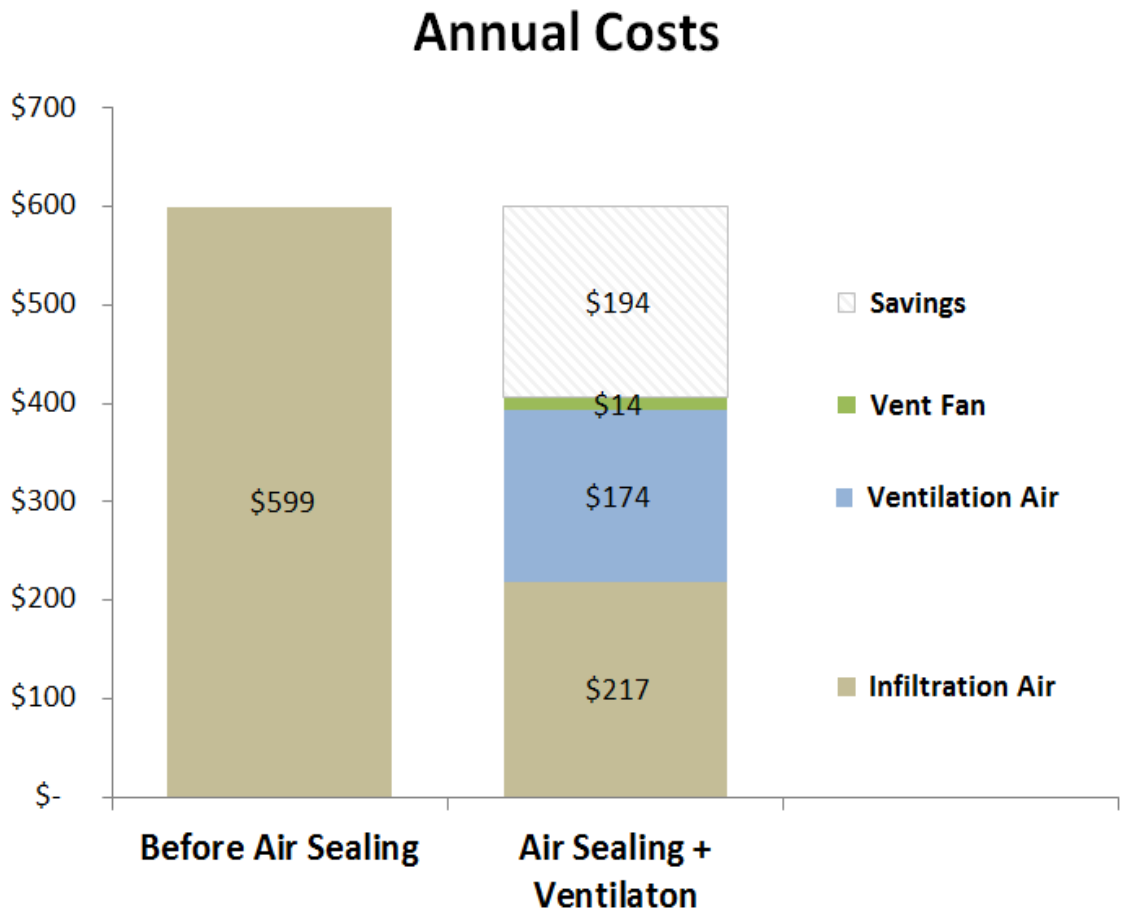
Cost of Infiltration vs Ventilation



Before:
16 ACH50

After:
4.5 ACH50

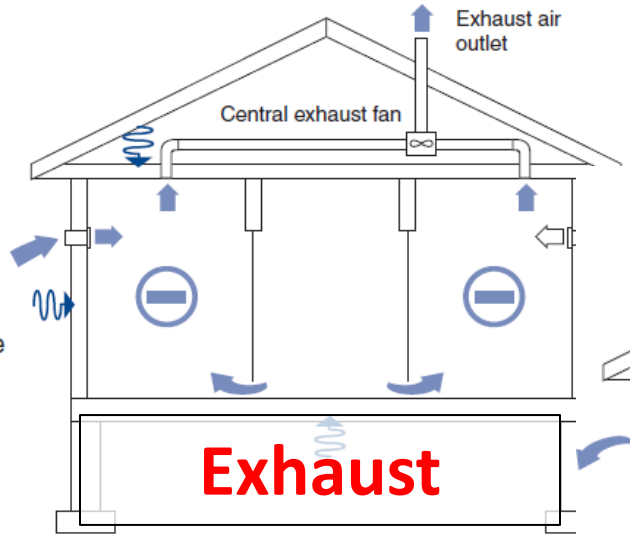
Cost of Infiltration vs Ventilation

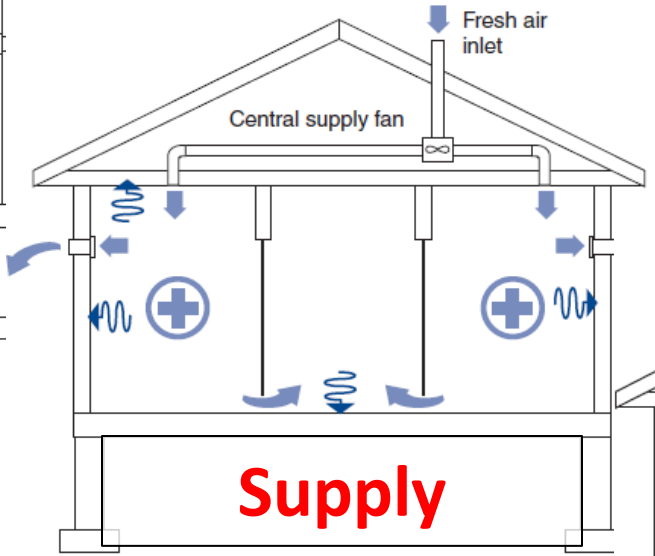


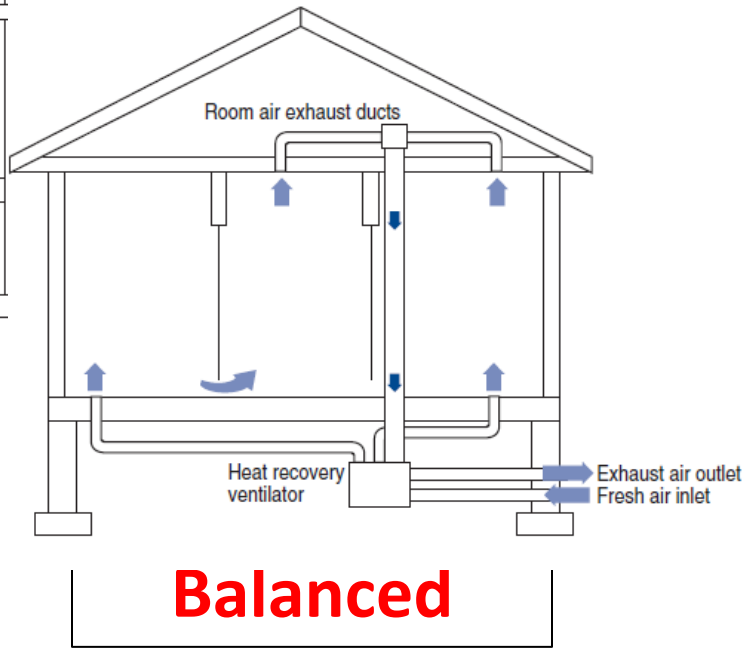
ACTIVITY

- Dilution example exercise

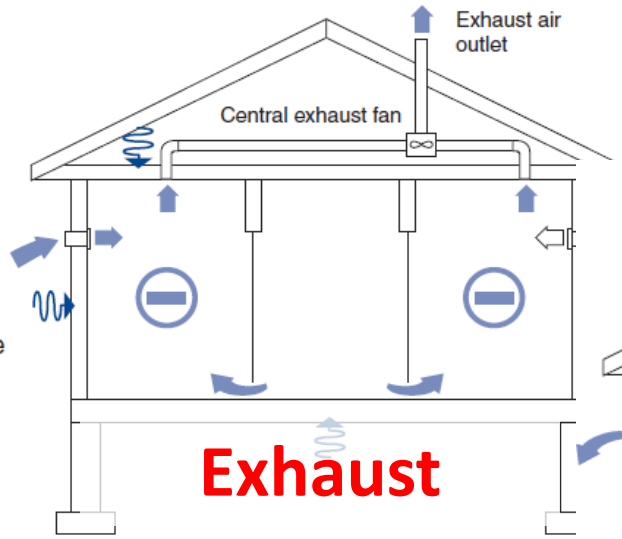
Determine Ventilation Strategy





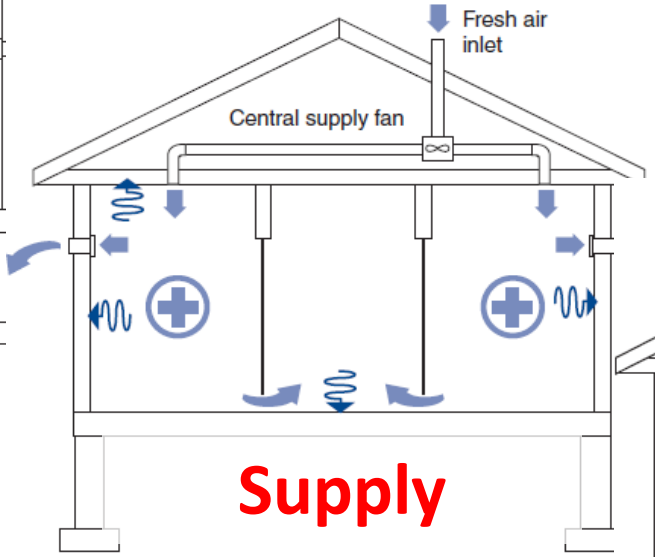


Continuous or Intermittent?



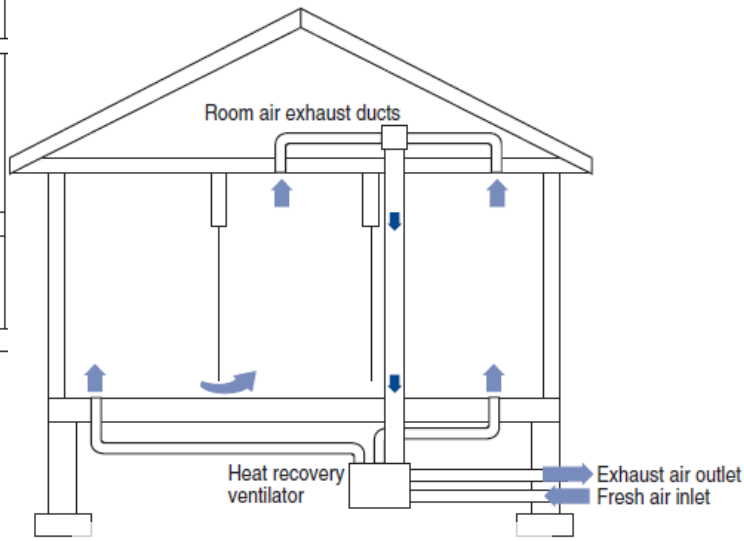
Exhaust

Working with bath fan



Supply

Working with air handler



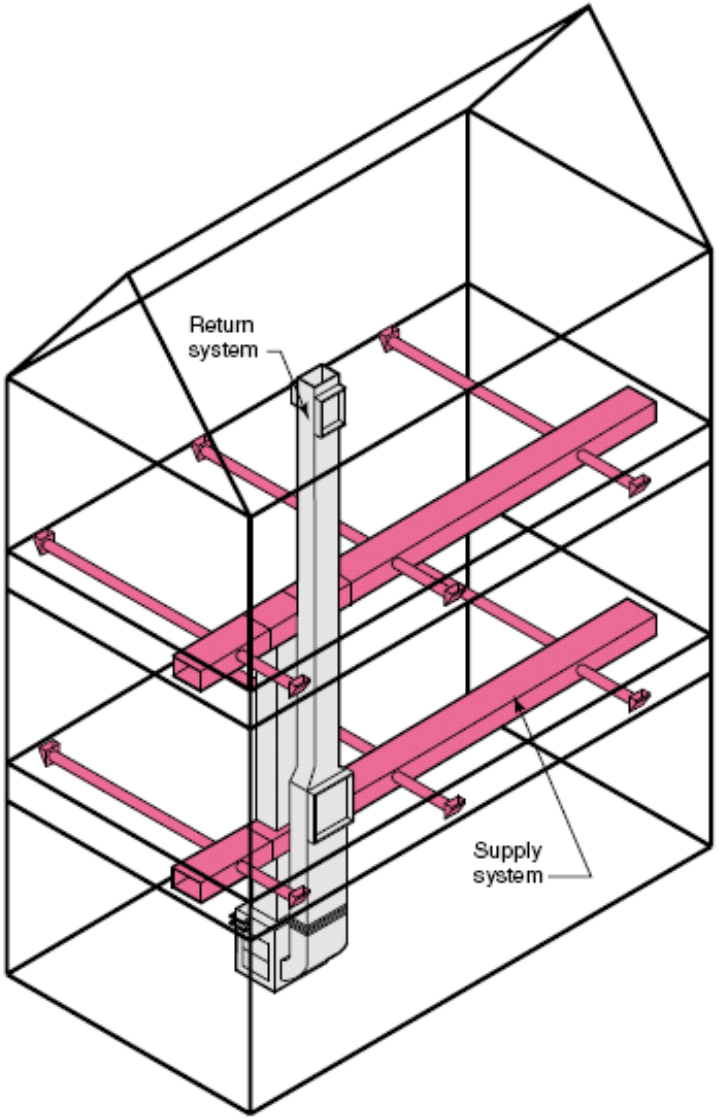
Balanced

Working with bath fan and/or air handler

Are other systems involved?

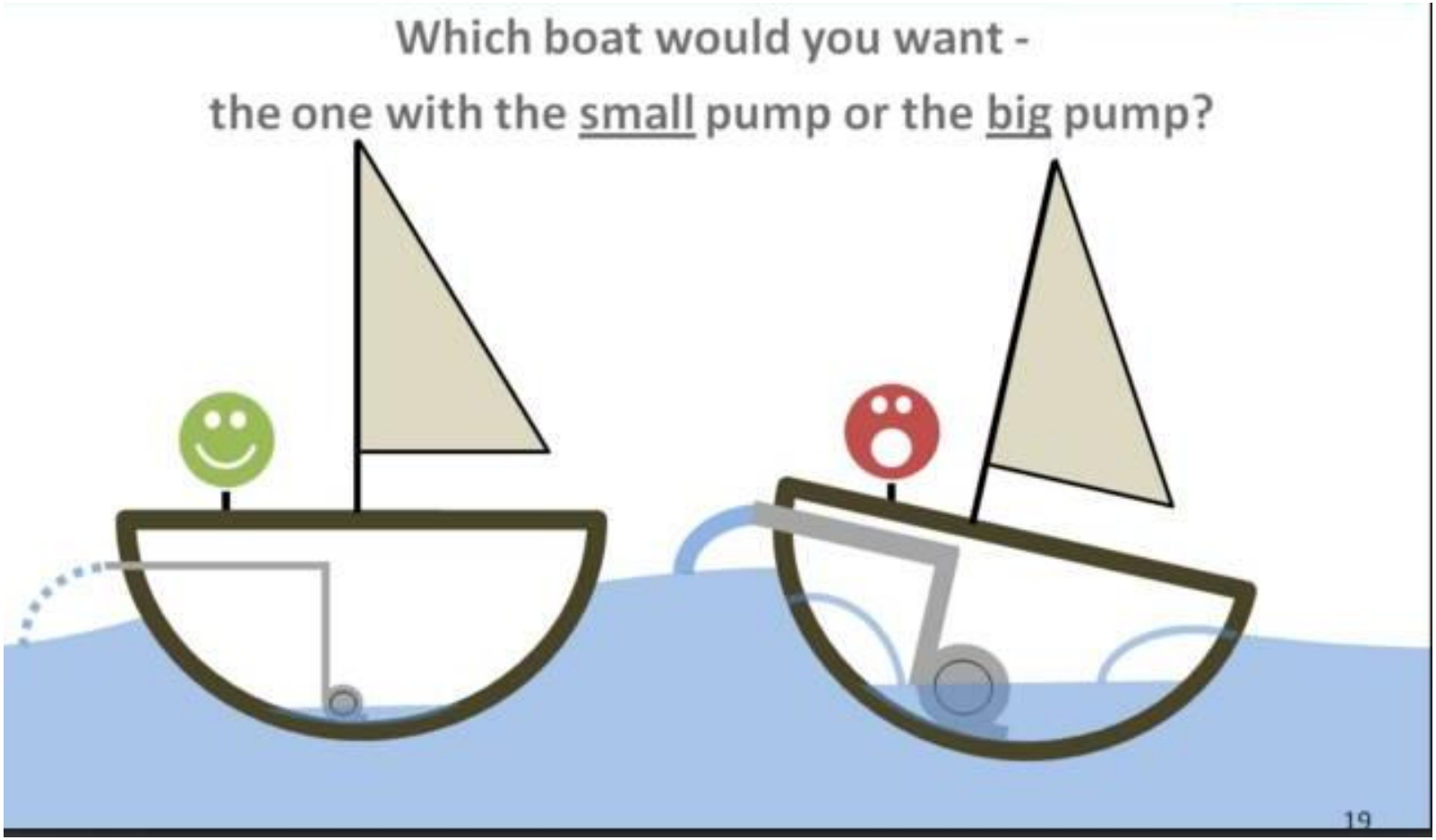
Considerations

- Exhaust
  - Delay timer
  - Boost switch for low to high
- Supply
  - Interlock with air handler
  - Controls to adjust time setting and flow rate
- Balanced
  - Interlock with air handler if using central ductwork
  - Bath fan relay and delay timer if using exhaust
  - Controls to adjust time setting and flow rate



HVAC by design

A right-sized and properly installed heating and cooling system cost less and removes humidity better



Heating/Cooling System Sizing
Why it matters

- Decrease energy use
- Oversizing HVAC leads to humidity issues, possible mold and other moisture failures
- Most MEPs and HVAC contractors want to oversize
  - they don't trust the quality of installation of envelope (or even HVAC equipment)
- Improves comfort and reduces noise

HVAC Sizing Calculations

Ensure equipment and ducts are properly sized for optimal operational efficiency

Use ACCA Manual J for residential spaces

Problem

- Does not reflect building components
- Performed after equipment installed
- Done just for code or ‘LEEDs people’

Know Your Code:

Duct Leakage

2009 IECC

- **Option 1:** Rough-in test –
  Total leakage is less than 6% of conditioned floor area
  –OR–
  4% if air handler is not installed at rough-in testing.

- **Option 2:** Post-construction test –
  Leakage to outdoors is less than 8% of conditioned square footage (tested in conjunction with blower door test)

2012 IECC

- **Option 1:** Rough-in test –
  Total leakage is less than 4% of conditioned floor area
  –OR–
  3% if air handler is not installed at rough-in testing.

- **Option 2:** Post-construction test –
  Leakage to outdoors is less than 4% of conditioned square footage (tested in conjunction with blower door test)

Duct Location

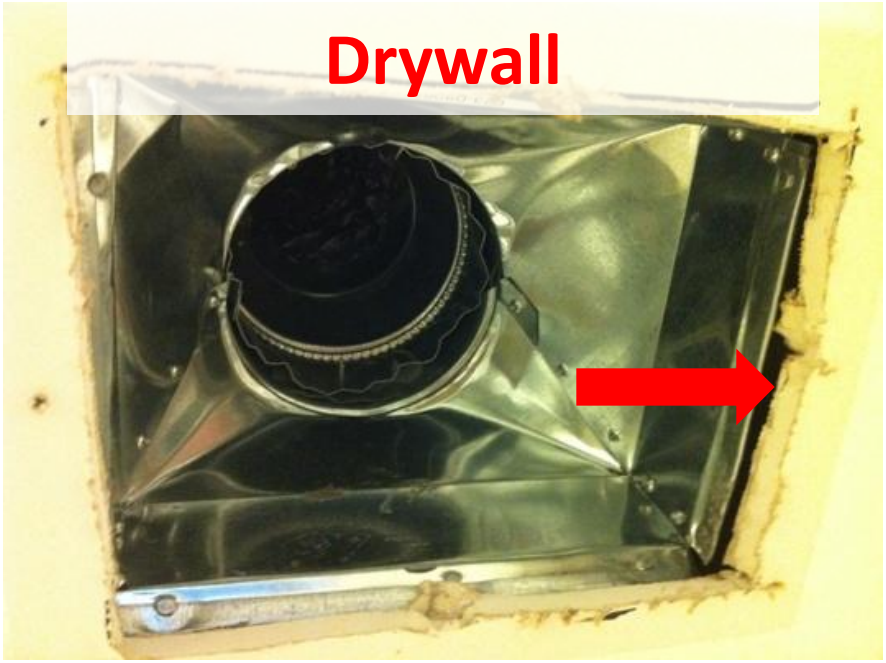
Seal all ductwork with Mastic

Seal air handler and tape seams

Mastic even at floor to duct connection

Duct Leakage –

Boot Not Sealed to Drywall



What’s wrong with this duct connection?

The Fix

The zip-tie fastener does not seal the joint, it only keeps the flex duct in place.